Impact analysis of options for implementing Article 7a of Directive 98/70/EC - Revised 2020 baseline fuel mix and costs

15 April 2013

Agenda

Objectives of study

Task 1: Development of baseline

- 1.1 Fuel projections
- 1.2 GHG emissions
- 1.3 Costs

Objectives of study

To underpin analysis of regulatory options and associated economic and GHG impacts for implementation of Article 7a method for calculating GHG emissions from fossil fuels for road vehicles

Task 1.1: Develop baseline EU fuel & feedstock projections in 2020

Preliminary assessment → Short list of options

- 15 studies / models assessed
- Evaluation criteria
  - scope
  - level of disaggregation
  - time horizon
  - policies considered
  - accessibility
- 5 studies / models shortlisted for next step

Task 1.1: Develop baseline EU fuel & feedstock projections in 2020

Detailed assessment → Approach for developing projections

- Evaluation criteria
  - *Modelling domain*: road transport sector / FQD fuels, EU27, feedstock & fuel types
  - *Data quality*: reliable, peer-reviewed, and accepted by the scientific / technical community
  - *Transparency*: assumptions readily accessible
  - *Modelling inputs*: key endogenous and exogenous variables to be outlined
  - *Technical consideration*: assumptions must be technically feasible and achievable
  - *Regulatory considerations*: Renewable Energy Directive (RED), CO_2 limits from cars and vans, justified estimate for the penetration of electric vehicles
- Summary of ratings

(Legend: ● Good ◐ Average ○ Poor).

Reports	*WORLD Model*, EnSys	*SULTAN Tool*	*The World Energy Outlook 2012*, International Energy Agency (IEA)	*International Energy Outlook 2011*, EIA/DOE (USA)	*Impact of the use of biofuels on oil refining and fuels specifications*, Wood Mackenzie
Modelling domain	●	○	◐	○	◐
Data quality	●	●	◐	◐	◐
Transparency	●	◐	◐	◐	○
Modelling inputs	●	●	◐	◐	◐
Technical considerations	●	◐	●	●	●
Regulatory considerations	◐	●	●	◐	◐

Task 1.1 World Model Regions

The model formulation aggregates the world into 22 regions:

Europa North West: (AT, BE, DE, DK, FI, FR, IE, LU, NL, SE, UK)
Europe South: (CY, EL, ES, IT, MT, PT, SI)
Europe East: (BG, CZ, EE, HU, LT, LV, PL, RO, SK)
Russia/FSU
Caspian
Middle East
Pacific Industrialized (Japan/Australasia)
Pacific Industrialized (High Growth)
China
India/Rest of Asia
US East Coast (PADD1)
US Mid West (PADD2)
US Gulf Coast (PADD3)
US Rocky Mountain (PADD4)
US West Coast (PADD5)
Canada East
Canada West
Greater Caribbean Including Mexico
South America
African North & Eastern Mediterranean
Africa West
Africa South/East

Task 1.1: Crude & fuel trade modelling approach (WORLD model)

- Utilized the 2020 baseline fuel demand from the IEA WEO 2011 Current Policies Scenario.
- The WEO does not provide EU27 specific crude trade and balance, therefore the WORLD model output was used for indication of the crude feedstocks and product trade.
- WORLD model was run without the FQD fuel GHG intensities in the 2020 baseline. In other words, the model was run as if the FQD did not exist.
- Projected demand by product category & grade (inc 10ppm diesel & other diesel grades) exogenous inputs
  - "Top down" scenario on demands by region
  - "Bottom up" detail on product grades & qualities
- Production of fuels (inc 10ppm diesel) calculated endogenously
- Product production and inter-regional flows result from simulations of operations, technology & economics of world petroleum / liquids industry
  - Using all available options (crude shipping, refinery processing, refinery investment, blending, intermediates & product shipping)
  - Satisfying product demand feasibly and optimally (at minimum global cost)
  - Respecting constraints (supply limits, shipping limits, process capacity & operational limits, product blending specs, regional product demands, etc)
- Some exogenous limits on crude and product movements
  - Crude movement limits based on geo-political considerations e.g. no Iranian crude to USA, steady growing VZ crude exports to China
  - Product exports from Russia 'semi-exogenous' as 'normal economics' not always worked – range set exogenously (historical trends, IEA data etc), endogenous flexibility within range

Task 1.1: Key input data

Energy prices

- Global oil price, input as price of marker crude $118/bbl in 2020 – IEA WEO Current Policy Scenario
- Natural gas prices, coal price relationships, other energy prices
- GHG emissions costs – EU refineries assumed to pay full price of carbon in 2020

Carbon prices

- EU ETS: assumed that EU refineries pay the full cost of their CO2 emissions in 2020.
- The EU ETS carbon price of €16.5/ tCO2e. The price was provided by the commission.

Biofuels

- The Commission provided the 2020 biofuel quantities and their feedstock-based GHG intensities. Biofuel origin was not modelled. Blend wall constraints were not modelled but are not expected to be an issue assuming future HVO and ETBE supply.

Task 1.1: Key input data (continued)

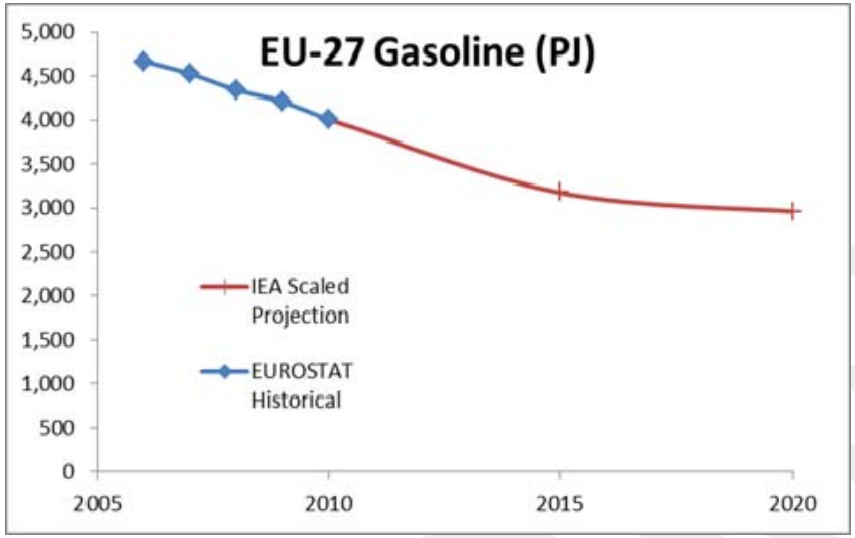
- Feedstocks
  - Crude: production outlook including balance of OPEC vs. non-OPEC
  - Fossil fuels based on total fuel demand minus biofuels
- Fuel / energy products:
  - IEA WEO 2011: 2020 total demand (current policy scenario), IEA Midterm Outlook 2012 product splits for each MS received from IEA (gasoline, diesel, etc)
  - SULTAN (electricity, CNG)
  - Product quality: evolution of standards / specs by region
- Oil refining (base capacity, new projects, new technologies)
- The model base refinery capacity for Europe only allowed for recent announced refinery closures of 1.6 mbd.
- Product and crude transport (marine, pipeline, rail)
- Adjustments: Europe to EU27, transport LPG

Task 1.1: Key Input Data -Fuel projections for EU27 road transport sector

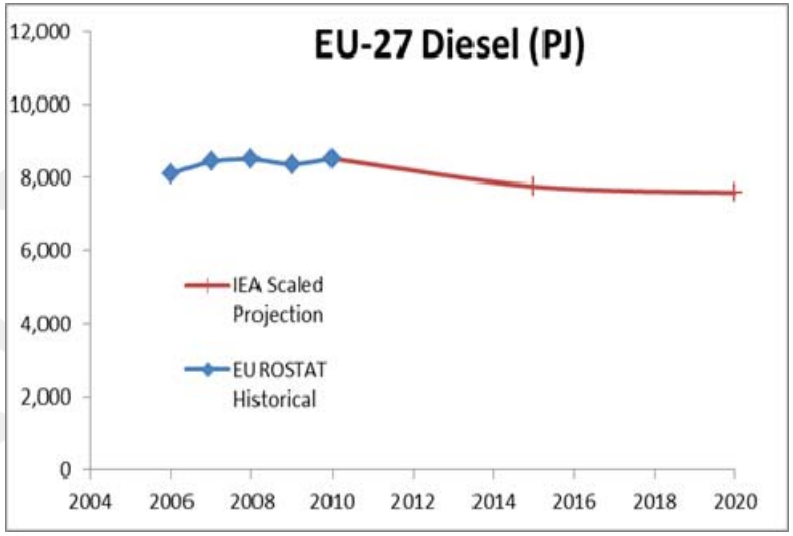
Fuel	2020 (1000 bpd)	2020 (PJ)
Gasoline	1,593	2,958
Diesel (10 ppm Sulphur Max)	3,633	7,590
Diesel On Road	3,187	6,659
Diesel Off Road	446	931
Electricity	N/A	113
LPG	141	208
CNG	84	44
Kerosene	0	0
Ship Fuel	0	0
TOTAL	5,451	10,912

Task 1.1: Trends in fuel projections

Gasoline Demand in EU-27, 2006 – 2020



Diesel Demand in EU-27, 2006 – 2020



Task 1.1: Key Input Data - 2020 Biofuel projections for EU27 road transport sector

Biofuel Feedstock	Baseline 2020 (Mtoe)	Baseline 2020 (PJ)	GHG Intensity (gCO2e/MJ)
Corn (maize)	0.69	28.59	33
Sugar beet	0.96	40.20	27
Sugar cane	2.47	103.11	20
Wheat Process fuel not specified	0.36	14.86	50
Wheat Natural gas as process fuel in CHP plant	0.36	14.86	50
Wheat Straw as process fuel in CHP plant	0.36	14.86	50
2G ethanol - land using	0.23	9.70	17
2G ethanol - non-land using	0.23	9.70	9
2G biodiesel - land using	0.37	15.34	5
2G biodiesel - non-land using	0.37	15.34	9
Waste 1st. Gen. diesel	0.74	30.67	9
Palm oil	1.96	82.18	51
Palm oil with methane capture	1.96	82.05	29
Rapeseed	9.20	385.29	40
Soybean	2.50	104.98	47
Sunflower	0.94	39.66	32
TOTAL	23.71	991.4	

Model Assumptions

EU 27 Products Demand & Biofuels Supply/Demand

Premise	Value(s) Used	Comment
EU27 Products Demand & Biofuels Supply/Demand		
EU Products Demand	Total EU liquids demand splits by major product category were taken from IEA 2012 Midterm Outlook 2017 horizon and then extrapolated to match the 2020 WEO projected demand using the 2017 demand splits. The resulting 2020 EU demand was then factored up to a corresponding WORLD Europe set of demands and finally petrol and diesel volume demands adjusted upward slightly to allow for the lower energy contents of ethanol and biodiesel versus conventional fuels.	
Product Specifications Diesel and Petrol	The WORLD model classifies any diesel that contains 50ppm sulphur or less as "ULSD" reflecting common industry use of the term. The model distinguishes and set specs for each region (e.g. US is nominal 15ppm, Europe is 10ppm). Other specifications can also be different, e.g. say gravity limits. Critically, the product specs operate such that product shipped from one region to another in WORLD must be produced (refined) to the specs of the destination region; so, for example, ULSD moved in a WORLD case from the US (or elsewhere) to Europe meets the European spec.	
EU CNG LNG demand	A small amount of EU CNG consumption was assumed by ICF in the energy demand calculations.	These streams not modelled in WORLD
EU ethanol supply and demand	EC provided production volumes/mix based on Members' projections. No imports or exports of biofuels were allowed	
EU biodiesel supply and demand	EC provided production volumes/mix based on Members' projections. No imports or exports of biofuels were allowed	

Model Assumptions (continued)

Overall world oil price/supply/demand outlook – IEA WEO 2011 Current Policies Case

Premise	Value(s) Used	Comment
Overall world oil price/supply/demand outlook – IEA WEO 2011 Current Policies Case		
Crude price	WEO basis is $118/bbl ($2010). This was adjusted (a) to the WORLD Model basis of $2011 and (b) to subtract off estimated freight to arrive at an FOB price which was applied to the marker crude in the Model, namely Saudi Light.	Basis for the WEO price is understood to be average IEA member import (landed) price.
Global supply / demand	WEO total supply and demand for 2020 under Current Policies scenario is 96.7 mb/d, but with 2.1 mb/d of biofuels supply stated as barrels of equivalent petrol/diesel. Since WORLD works on volume barrels, the 2.1 mboe/d biofuels supply was adjusted to an estimated 2.95 mb/d (see below) and global volume supply and demand were each correspondingly adjusted, i.e. by +0.85 mb/d to 97.55 mb/d.	WORLD internal demand projections for 2020 adjusted to hit 97.55 mb/d total global demand after first adjusting European demands to fit IEA-based projection
Global biofuels supply	IEA Current Policies projects 2.1 mb/d 2020 oil equivalent. EnSys estimated this equates to around 2.95 mb/d in volume terms and applied this total	EU ethanol and biodiesel production volumes were higher than in internal WORLD projection so other regions' supply prorated down to accommodate the higher EU numbers and hit the IEA global target.
OPEC/non-OPEC supply	The data available in the WEO for 2020 Current Policies supply (Table 3.4) show OPEC and non-OPEC crude, NGL's and non-conventionals but do not provide any breakdown of these. Consequently, EnSys adjusted (non-biofuels) supply to meet the same ratio of OPEC to non-OPEC supply as in the WEO. The adjustments were small.	
Crudes supply	Within WORLD, "top level" regional supply of oil liquids is taken from a third party projection, e.g. IEA or EIA, and then broken down to first subtract out non-crudes supplies (often these are split out in the projection). Total crude supply for a given region is then split out between the relevant crude grades based on extensive in-house research and data on current and projected crude production by main crude grade. This process includes both conventional and non-conventional crude oils. In any WORLD case, production levels are for all individual crude grades except for the marker/marginal crude (generally Saudi Light is used). An input price is assigned to the marker crude based on the projection for world crude price.	Non-crudes supplies for all except methanol (for MTBE feed) and natural gas (for hydrogen plant feedstock and refinery fuel) are also projected and fixed in any given case. (Prices are assigned to methanol and natural gas.) Product demands are worked up in a similar way and are fixed for all except the refinery by-products of sulphur and fuel grade petroleum coke (which are given prices and allowed to float). The effect is that, within any one case, the prices of every crude except the marker and of every non-crude and product are outputs from the case – not inputs.

Model Assumptions (continued)

Refinery Data

Premise	Value(s) Used	Comment
Refinery Data		
Base capacity, projects and closures	Internal WORLD data used. European Union projects were checked and reconciled against data supplied by EC.	Note, in current WORLD model, total refining capacity is aggregated in each of the 3 European Model regions.
Process technology and economics	Internal WORLD data	
Product blending and quality / specifications	Internal WORLD data and projections taking account of actual blended qualities versus specifications. Progressive trend to LS/ULS standards in non-OECD regions	
Marine fuels	MARPOL Annex VI 0.1%S for ECA's in 2015. No new ECA's by 2020 beyond Europe (2) and Canada/USA. In line with IEA assessment, date for implementation of 0.5% sulphur global standard put back to 2025. However, EU rule passed in September 2012 that requires 0.5% sulphur fuel to be consumed in all EU	Effect of shifting the assessed implementation date for global 0.5% fuel to 2025 was to cause a shift in all world regions back from marine distillate to IFO – versus a 2020 implementation assumption – partially offset in Europe by an assumed impact of the EU 0.5% 2020 standard in shifting some IFO consumed in (mainly southern and eastern i.e. non-ECA) Europe to marine distillate.
EU petrol and diesel specifications	Internal WORLD data checked to ensure consistency against -supplied data, including for ethanol-in petrol vapour pressure waiver	
EU Carbon regime / cost	EU ETS €16.5/ tCO2e assumed for carbon price. Assumed in modelling that EU refiners pay carbon price on 100% of their CO2 emissions	Euro/dollar exchange rate 1.25 hence dollar cost of $20.60 /tCO2E. Note, an energy efficiency trend was allowed for in the case but the option to "buy" more energy efficient means to generate steam/power and/or to consume fuel/steam/power more efficiently would have to be built in to the model
Other carbon regimes	No other major regimes assumed except for California LCFS which blocks WCSB oil sands crudes from being processed in the state	

Model Assumptions (continued)

Logistics and Trade

Premise	Value(s) Used	Comment
Logistics & Trade		
Marine routes, tanker types, freight rates	Extensive movements for crudes and products basis internal WORLD data based on WorldScale. Panama Canal expansion by 2015	Movements generally not constrained other than where there are clear known situations that force or prevent specific movements e.g. for geo-political reasons or where crudes are known to be refined locally. Examples that are actively incorporated within the WORLD Model include: projected gradually increasing volumes of Venezuelan crude shipped to China to reflect geo-political ties and deals between the two countries, no Iranian crude to USA, requirements that selected crude oils in oil-producing countries be refined locally based on knowledge of the refineries there.
Pipelines	Inter-regional pipelines, basis WORLD internal data/projections, including: USA/Canada pipelines and rail: TransMountain expansion to 750,000 b/d assumed by 2020 but not Northern Gateway (affects volumes of WCSB crudes moving to BC and Asia versus into US/eastern Canada), total WCSB capacity to Gulf Coast over 1.7 million b/d pipeline (Seaway, KXL, Pegasus) plus rail at 200,000 b/d. Total capacity 1.9 million b/d. Other crudes also utilize this capacity. Russian ESPO pipeline capacity to Komsomolsk / Asia 1.5 million b/d	

Model Output and Results

The results presented in this report on feedstock and product projections should be regarded as indicative rather than definitive.

- 2020 base case projection of 10.2 mbd refinery throughput for WORLD Model Europe based on estimated 2020 demand from IEA projections of 13.04 mbd
- Versus 2011 actual, projected demand drops by nearly 2.3 mbd but projected refinery throughput drops by 2.9 mbd, i.e. refinery throughput drops by more than demand. This reduction is dependent on and sensitive to competition from other regions, has an underlying assumption that product exports from the FSU will continue to slowly grow, and incorporates assumed carbon costs of €16.5/ tCO_2e on European refinery operations, which will tend to cut European refinery throughputs.
- World Model Europe projected refinery base capacity of 16.4 mbd, and projected 2020 throughput of 10.2 mbd, resulting in refinery utilisation of 62%. Long term sustainable refinery utilisation of 85% would imply a further 4.4 mbd of closures across Europe.
- Distillates are projected to continue to maintain a significant price premium over petrol and thus 2-1-1 crack spreads well ahead of 3-2-1.
- 2020 European crude slate is projected at 51% sweet, of which the sweet grades are predominantly North and West African.

Model Output and Results (continued)

- 2020 European crude slate includes 6,700 b/d of oil shale, all sourced from Estonia.
- All product imports modelled are derived from conventional feedstocks with the exception of US diesel arriving from the Gulf coast (USGC), GTL arriving from Africa and Latin America. CTL is produced in Europe North region.
- The 2020 base case assumes the ESPO pipeline system in full operation which increases Russian crude exports to Asia. Projected ESPO 2020 capacity is 1.5 mbd with total throughput in the case running at 1.3 mbd of which around 0.4 mbd runs on the spur into China and the rest out to the Pacific.
- Total product exports from the model Europe regions are projected at 1.7 mbd and imports at 2.4 mbd.
- Canadian bitumen crudes are not predicted to come across to Europe. However Venezuelan bitumen is imported to Europe. And Canadian bitumen derived diesel is imported to Europe from the USA (USGC).

Task 1.1: Model Output: 2020 Crude Trade

- 2020 model crude trade projections should be interpreted as indicative but should not be taken as definitive.
- Crudes of similar quality, i.e. a South American heavy or Saudi Heavy or other Middle Eastern heavy grade, can replace each other, relevant to market prices at the time.
- Compared to 2010, the model base case projected that in 2020 crude imports into Europe from Africa and Latin America would increase while crude imports from Former Soviet Union (FSU) nations would decrease.
- Overall, crude demand would be appreciably lower as a result of efficiency increases and a larger market share of biofuels and renewable energy.
- Clearly there is uncertainty in the base case projection and, if premises were changed on the above production/logistics or other parameters, the outlook would change.
- Overall, the IEA projections are in close accord with those from the model base case.

Crude by Region of Origin	Percent of Total
% European	22%
% FSU/Caspian	18%
% African	42%
% Middle Eastern	14%
% Latin American	6%
% Total	**100%**

Task 1.1 2020 FSU Crude Trade

- Model forecasts FSU crude decreasing into Europe over time due to a combination of:
  - relatively flat crude oil production for the region with;
  - increased capacity on the ESPO system which will take Russian crude to China and other Asia (the other FSU crudes into China/Asia are Caspian crude via pipeline to China and Sakhalin crudes) and
  - forecasted domestic FSU demand slowly growing and a new taxation regime that could encourage product exports in preference to crude.
- The IEA Midterm 2012 forecasts total FSU crude exports to decline by 600 kb/d to 6.0 mb/d by 2017 compared to 2011, as increasing domestic demand cuts into volumes available for export.
- IEA expects the FSU to continue to diversify export destinations with more oil being shipped eastwards. China is seen doubling its imports of regional crudes to 1.2 mb/d while 'Other Asia' is expected to take 300 kb/d more oil in 2017 than 2011.
- IEA forecasts OECD Europe will decrease FSU crude imports by 1.2 mb/d in 2017 compared to 2011.

Task 1.1 African Crude Trade

- Model forecasts African crudes increasing into Europe over time due to a combination of:
  - Africa is forecast to have the one of the strongest annual production growth rates of all exporting regions.
  - As most African crudes are traded on spot markets, whereas Middle Eastern streams tend to be sold to term buyers, Africa has historically served as a swing supplier, shifting its crude exports' direction east or west depending on market conditions.
  - The base case forecast is for North Sea production to continue to decline leaving a sweet crude deficit, filled by African crudes
  - Changing import requirements in North America have already reduced imports from West Africa to the US. In the base case, this trend is forecast to continue, i.e. that North America will continue to cut African imports as rising domestic light, sweet crude production displaces imports of African grades of similar quality in the Gulf Coast, East Coast and even the West Coast; also Eastern Canada.
  - As a result, and also because of the ESPO pipeline shift in FSU output eastward, African crudes are projected to go to Europe with increasing volumes.
- IEA forecasts OECD Europe to increase crude imports from Africa by 900 kb/d in 2011 to take 3.0 mb/d by 2017.

Task 1.1 2020 EU Petrol Exports to US

- The most significant change to global petrol product balances derives from the changing North American energy landscape.
- The US is moving from being the world's largest importer of petrol to a position of much greater self-sufficiency, balancing East Coast imports with growing Gulf Coast exports to neighboring Mexico and several Latin American countries.
- The forecast of EU exports of 0.61 mbpd gasoline to the US by 2020 was based on East Coast refineries would continue to be under pressure, and reflected a continuation of the recent trend of closures in the region.
- The base case did not assume domestic crude supplies into the US northeast in the volumes which latest data indicate could be soon operational (via rail). These developments could, especially if also supported by regional tight oil growth (notably the Utica shale), act to sustain East Coast refining activity and prevent the continued capacity decline reflected in the base case.

Task 1.1: Impact of EU-ETS carbon price

- EU refineries are assumed to pay full carbon price of €16.5/ tCO2e in 2020
- The effect of putting a cost on European refiners' production of CO2 will attract in / make more valuable in Europe crudes that require less processing. This reinforces the shift toward African sweet grades and the backing out of sourer crudes.

Task 1.1: Model Output: 2020 Fuel Trade

The estimated EU27 demand for energy from fuels decreases from 12,753 PJ in 2010 to 10,912 PJ in 2020

Fuel	Consumption by Fuel for 2010 (bbl/year)	Consumption by Fuel for 2010 (PJ)	Consumption by Fuel for 2020 (bbl/year)	Consumption by Fuel for 2020 (PJ)
Petrol	786,675,652	4,002	581,337,770	2,958
Diesel	1,490,643,574	8,532	1,326,137,339	7,590
Electricity	n/a	n/a	n/a	113
Hydrogen	0	0	0	0
LPG	54,388,492	219	51,628,467	208
CNG	n/a	n/a	30,671,568	44
LNG	0	0	0	0
Kerosene	0	0	0	0
Ship Fuel	0	0	0	0
TOTAL	**2,331,707,718**	**12,753**	**1,989,775,144**	**10,912**

The exhibits on the following slides summarize the results of the model's projected fuel trade based on the EU-27 demand

Task 1.1: Model Output: 2020 Product Prices

Product	EUR-No	EUR-So	EUR-Ea
	$/bbl	$/bbl	$/bbl
LPG	$ 106.86	$ 106.24	$ 108.26
PETCHEM NAPHTHA	$ 108.54	$ 107.62	$ 109.73
GASOLINE - PREMIUM	$ 120.13	$ 116.32	$ 118.54
GASOLINE - REGULAR	$ 117.65	$ 113.81	$ 115.78
JET A1	$ 139.65	$ 138.01	$ 136.84
ULSD	$ 142.24	$ 140.75	$ 139.84
RESID .3-1.0%	$ 114.14	$ 116.51	$ 117.90
IFO380 HS	$ 112.68	$ 112.26	$ 116.26

All prices given in 2011 U.S. Dollars.

Task 1.1: Model Output: 2020 Petrol Trade (Fossil and Biofuel)

Region	Total Exports (mbpd)	Total Local + Exports (mbpd)	USA& Canada (mbpd)	Latin America (mbpd)	Africa (mbpd)	EU-27 (mbpd)	FSU (mbpd)	Middle East (mbpd)	China (mbpd)	Other Asia/Pac (mbpd)
USA & Canada	**0.57**	**8.76**	**8.18**	0.51	0.03	0.00	0.00	0.00	0.04	0.00
Latin America	**0.26**	**2.24**	0.26	**1.98**	0.00	0.00	0.00	0.00	0.00	0.00
Africa	**0.09**	**0.84**	0.09	0.00	**0.75**	0.00	0.00	0.00	0.00	0.00
EU-27	**0.93**	**2.60**	0.61	0.00	0.26	**1.67**	0.06	0.00	0.00	0.00
FSU	**0.00**	**1.20**	0.00	0.00	0.00	0.00	**1.20**	0.00	0.00	0.00
Middle East	**0.20**	**1.78**	0.00	0.00	0.01	0.00	0.00	**1.58**	0.00	0.19
China	**0.07**	**2.65**	0.00	0.00	0.00	0.00	0.00	0.00	**2.58**	0.07
Other Asia/Pac	**0.09**	**3.38**	0.07	0.00	0.02	0.00	0.00	0.00	0.00	**3.28**
Total Imports	**2.21**		**1.02**	**0.51**	**0.33**	**0.00**	**0.06**	**0.00**	**0.04**	**0.26**
TOTAL Imports + Local		**23.43**	**9.20**	**2.49**	**1.08**	**1.67**	**1.26**	**1.58**	**2.62**	**3.54**

Task 1.1: Model Output: 2020 ULSD (Fossil and Biofuel) Trade

Region	Total Exports (mbpd)	Total Local + Exports (mbpd)	USA& Canada (mbpd)	Latin America (mbpd)	Africa (mbpd)	EU-27 (mbpd)	FSU (mbpd)	Middle East (mbpd)	China (mbpd)	Other Asia/Pac (mbpd)
USA & Canada	**0.10**	**4.35**	**4.24**	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Latin America	**0.00**	**0.47**	0.00	**0.47**	0.00	0.00	0.00	0.00	0.00	0.00
Africa	**0.00**	**0.27**	0.00	0.00	**0.27**	0.00	0.00	0.00	0.00	0.00
EU-27	**0.00**	**2.99**	0.00	0.00	0.00	**3.14**	0.00	0.00	0.00	0.00
FSU	**0.86**	**1.07**	0.00	0.00	0.00	0.41	**0.12**	0.00	0.00	0.00
Middle East	**0.03**	**0.71**	0.00	0.00	0.00	0.00	0.00	**0.68**	0.00	0.03
China	**0.00**	**1.12**	0.00	0.00	0.00	0.00	0.00	0.00	**1.12**	0.00
Other Asia/Pac	**0.00**	**2.10**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.10**
Total Imports	**0.99**		**0.00**	**0.00**	**0.00**	**0.51**	**0.00**	**0.00**	**0.00**	**0.03**
TOTAL Imports + Local		**12.67**	**4.24**	**0.47**	**0.27**	**3.65**	**0.12**	**0.68**	**1.12**	**2.13**

Task 1.1: Model Output: 2020 Distillate (Fossil and Biofuel) Trade

Region	Total Exports (mbpd)	Total Local + Exports (mbpd)	USA& Canada (mbpd)	Latin America (mbpd)	Africa (mbpd)	EU-27 (mbpd)	FSU (mbpd)	Middle East (mbpd)	China (mbpd)	Other Asia/Pac (mbpd)
USA & Canada	**1.08**	**5.81**	**4.73**	0.63	0.18	0.10	0.00	0.00	0.02	0.15
Latin America	**0.01**	**2.36**	0.00	**2.35**	0.01	0.00	0.00	0.00	0.00	0.00
Africa	**0.01**	**1.41**	0.00	0.00	**1.40**	0.01	0.00	0.00	0.00	0.00
EU-27	**0.16**	**4.35**	0.00	0.00	0.16	**4.20**	0.00	0.00	0.00	0.00
FSU	**0.96**	**2.15**	0.00	0.00	0.07	0.90	**1.18**	0.00	0.00	0.00
Middle East	**0.71**	**2.97**	0.00	0.00	0.01	0.00	0.00	**2.26**	0.00	0.70
China	**0.00**	**5.58**	0.00	0.00	0.00	0.00	0.00	0.00	**5.58**	0.00
Other Asia/Pac	**0.00**	**5.25**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**5.25**
Total Imports	**2.93**		**0.00**	**0.63**	**0.43**	**1.01**	**0.00**	**0.00**	**0.02**	**0.84**
TOTAL Imports + Local		**29.88**	**4.73**	**2.98**	**1.83**	**5.20**	**1.18**	**2.26**	**5.60**	**6.09**

Task 1.1: Model Output: 2020 CTL ULS Distillate Liquids Trade

Region	Total Exports (mbpd)	Total Local + Exports (mbpd)	USA&Canada (mbpd)	Latin America (mbpd)	Africa (mbpd)	EU-27 (mbpd)	FSU (mbpd)	Middle East (mbpd)	China (mbpd)	Other Asia/Pac (mbpd)
USA & Canada	**0.00**	**0.00**	**0.00**	0.00	0.00	0.000	0.00	0.00	0.00	0.00
Latin America	**0.00**	**0.00**	0.00	**0.00**	0.00	0.000	0.00	0.00	0.00	0.00
Africa	**0.04**	**0.15**	0.00	0.00	**0.11**	0.000	0.00	0.00	0.00	0.04
EU-27	**0.01**	**0.01**	0.01	0.00	0.00	**0.009**	0.00	0.00	0.00	0.00
FSU	**0.00**	**0.00**	0.00	0.00	0.00	0.000	**0.00**	0.00	0.00	0.00
Middle East	**0.00**	**0.00**	0.00	0.00	0.00	0.000	0.00	**0.00**	0.00	0.00
China	**0.06**	**0.21**	0.00	0.00	0.00	0.000	0.00	**0.00**	0.15	0.06
Other Asia/Pac	**0.00**	**0.07**	0.00	0.00	0.00	0.000	0.00	0.00	**0.00**	**0.07**
Total Imports	**0.11**		**0.01**	**0.00**	**0.00**	**0.000**	**0.00**	**0.00**	**0.00**	**0.10**
TOTAL Imports + Local		**0.44**	**0.01**	**0.00**	**0.11**	**0.009**	**0.00**	**0.00**	**0.15**	**0.17**

Task 1.1: Model Output: 2020 GTL ULS Distillate Liquids Trade

Region	Total Exports (mbpd)	Total Local + Exports (mbpd)	USA&Canada (mbpd)	Latin America (mbpd)	Africa (mbpd)	EU-27 (mbpd)	FSU (mbpd)	Middle East (mbpd)	China (mbpd)	Other Asia/Pac (mbpd)
USA & Canada	**0.05**	**0.11**	**0.06**	0.05	0.00	0.000	0.00	0.00	0.00	0.00
Latin America	**0.00**	**0.01**	0.00	**0.01**	0.00	0.001	0.00	0.00	0.00	0.00
Africa	**0.03**	**0.06**	0.00	0.00	**0.03**	0.029	0.00	0.00	0.00	0.00
EU-27	**0.00**	**0.00**	0.00	0.00	0.00	**0.000**	0.00	0.00	0.00	0.00
FSU	**0.00**	**0.02**	0.00	0.00	0.00	0.000	**0.02**	0.00	0.00	0.00
Middle East	**0.13**	**0.25**	0.00	0.00	0.00	0.000	0.00	**0.12**	0.00	0.13
China	**0.00**	**0.00**	0.00	0.00	0.00	0.000	0.00	**0.00**	0.00	0.00
Other Asia/Pac	**0.00**	**0.04**	0.00	0.00	0.00	0.000	0.00	0.00	**0.00**	**0.04**
Total Imports	**0.21**		**0.00**	**0.05**	**0.00**	**0.029**	**0.00**	**0.00**	**0.00**	**0.13**
TOTAL Imports + Local		**0.49**	**0.06**	**0.06**	**0.03**	**0.030**	**0.02**	**0.12**	**0.00**	**0.17**

Task 1.1: Model Output: 2020 LPG Trade ex NGL and Refineries

Region	Total Exports (mbpd)	Total Local + Exports (mbpd)	USA& Canada (mbpd)	Latin America (mbpd)	Africa (mbpd)	EU-27 (mbpd)	FSU (mbpd)	Middle East (mbpd)	China (mbpd)	Other Asia/Pac (mbpd)
USA & Canada	**0.36**	**1.96**	**1.60**	0.23	0.00	0.00	0.00	0.00	0.00	0.14
Latin America	**0.00**	**0.64**	0.00	**0.64**	0.00	0.00	0.00	0.00	0.00	0.00
Africa	**0.17**	**0.60**	0.04	0.00	**0.43**	0.10	0.00	0.00	0.00	0.04
EU-27	**0.00**	**0.55**	0.00	0.00	0.00	**0.55**	0.00	0.00	0.00	0.00
Transport LPG	-	-	-	-	-	0.14	-	-	-	-
Residential, commercial LPG	-	-	-	-	-	0.41	-	-	-	-
FSU	**0.01**	**0.49**	0.00	0.00	0.01	0.00	**0.47**	0.00	0.00	0.00
Middle East	**0.95**	**1.80**	0.00	0.00	0.00	0.09	0.00	**0.85**	0.00	0.86
China	**0.00**	**0.89**	0.00	0.00	0.00	0.00	0.00	0.00	**0.89**	0.00
Other Asia/Pac	**0.00**	**1.06**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.06**
Total Imports	**1.50**		**0.04**	**0.23**	**0.01**	**0.19**	**0.00**	**0.00**	**0.00**	**1.03**
TOTAL Imports + Local		**7.98**	**1.64**	**0.87**	**0.44**	**0.74**	**0.47**	**0.85**	**0.89**	**2.09**

Task 1.1 Factors Contributing to European Diesel and Petrol Market

- Several factors contribute to the current situation of the European diesel and petrol market, however; the structural decline in regional product demand is the most relevant.
- Global oil product balances will change by 2020 from the current situation in particular the transformation of the North American market.
- European net imports of oil products were more than halved during the last decade, to just over 500 kb/d in total in 2011.
- The EU's middle distillate imports averaged 830 kb/d, offset by petrol exports of 820 kb/d, while other products amounted to 500 kb/d of net imports (IEA Midterm 2012).
- A structural shift in demand, from petrol to diesel, is continuing to cause Europe's refiners problems as they have to find outlets for surplus petrol production, often at discounted prices.
- In 2020, EU27's petrol surplus will be approximately 0.93 mb/d based on ICF's forecast, while diesel and gas oil imports could surge to more than 1.01 mb/d as a result of capacity rationalization and lower throughputs.
- In the non-OECD, the FSU will remain the largest product exporter globally, with increasing export potential of both light and middle distillates through 2020 while refinery upgrades cut into fuel oil supplies.
- The major source of imports of 10ppm diesel into the EU is FSU. The model assumed there is investment in additional capacity in FSU, which is key to achieving the exports.

Task 1.2: Calculate baseline GHG emissions & GHG intensity

- The 2020 baseline is 83.67 gCO2e/MJ, a 5.2% reduction from the 2010 baseline of 88.3 gCOe/MJ, and exceeds the 83 gCO2e/MJ intensity target
- Fossil fuels: default values from Annex 1 of EC's 2011 proposal for GHG calculation methods (conventional crude, natural bitumen, oil shale etc.). Biofuels: provided by EC.
- In the 2020 forecast, petrol is 11.7 vol% ethanol, and diesel is 10.5 vol% biodiesel.

GHG Emissions by Fuel Type

Fuel	Feedstock	GHG Emissions	GHG Intensity	Fuel Consumption
		(MMT)	(gCO2e/MJ)	PJ
Gasoline	Conventional crude	232.09	21.27	2,652.40
	Natural bitumen (Venezuela to EU)	7.23	0.66	67.53
	Oil shale (EU)	0.23	0.02	1.79
Diesel	Conventional crude	584.38	53.55	6,558.71
	Natural bitumen (Venezuela to EU)	18.4	1.69	169.58
	Natural bitumen (Canada via USGC to EU)	2.32	0.21	21.38
	Oil shale (EU)	0.6	0.05	4.49
	CTL (EU)	3.24	0.3	18.83
	GTL (L.A. and Africa)	5.99	0.55	61.72
LPG		15.28	1.40	207.67
CNG		3.37	0.31	43.89
Electricity	EU-average	5.09	0.47	112.60
Ethanol		6.57	0.6	235.87
Biodiesel		28.68	2.63	755.50
	Total	**913.01**	**83.67**	**10,911.96**

Where. MMT = Million Metric Tons, PJ = Petajoule

Task 1.3: Assess Costs in the Baseline

- Approach
  - Cost of additional alternative transport fuels in 2020 baseline vs. 2010
  - The costs reported are for the absolute costs of the alternative fuels.
  - Incremental costs used for pricing compliance
  - Options
  - Bioethanol
  - Biodiesel
  - Electricity
  - CNG
  - LPG
  - Upstream flare / venting reductions

Task 1.3: Costs in the baseline, bioethanol

Bioethanol Feedstock	Cost element (€/GJ)				
	Feedstock	Transport	Operations/ Capacity	Co-product	Total
Corn	23 [c]		6.1 [c]	2.9 [c]	12-20 [a] 27 [c]
Sugar Beet	12-14 [a]		6.4 [c]	2.0 [a] 4.8 [c]	12-24 [a] 19 [c]
Sugarcane	4.5 [c] 28 [d] 7.5 [e]	4.1 [c] 5.5 [d] 4.7 [e]	4.6 [d] 6.4 [e]		15 [a] 12 [c] 18.6 [e]
Wheat	13-15 [a] 26 [d]	5.5 [d]	6.1 [c] 2.6 [d]	3 [a] 3.5 [c] 3.7 [d]	12-23 [a] 32 [c] 31 [e]
2G Ethanol	10-13 [a] 11 [c] 11 [d]	5.5 [d]	15-16 [a] 7.5 [c] 20.3 [d]	-5.8 [d]	25-28 [a] 18 [c] 31 [d]
Bioethanol					19 [b]

[a] Szabo et al.. Assessment of the GHG reduction potential and cost curves resulting from fuel substitution possibilities
[b] Estimating the Cost-Effectiveness of Biofuels, Defra, 2008
[c] Committee on Climate Change, UK
[d] Data from COWI's Danish model for alternative fuels, the A-D Model.
[e] Cargo et al. Competitiveness of Brazilian Sugarcane Ethanol Compared to US Corn Ethanol, 2010.

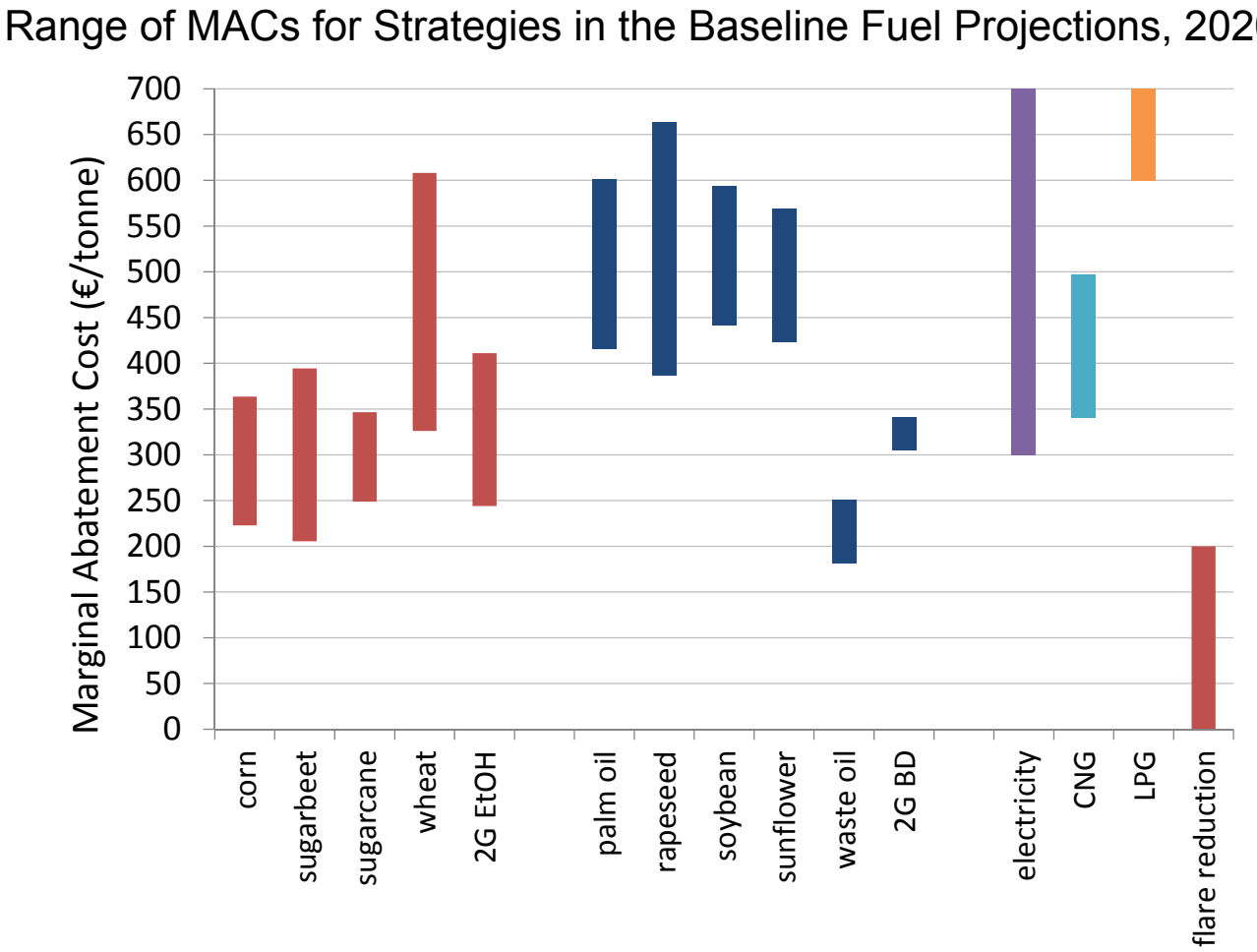
Task 1.3: Costs in the baseline, biodiesel

Biodiesel Feedstock	Cost element (€/GJ)				
	Feedstock	Transport	Operations/ Capacity	Co-product	Total
Rapeseed	27.9 [c] 31.8 [c] 22 [d]	3.8 [d]	2.1 [c] 4.9 [d]	1.4 [c] 11.9 [d]	11.8 – 17 [a] 22.3 [c] 32.6 [c] 19 [d]
Sunflower	20-23 [e]	1-4 [e]	3.3 [c] 2.1 [c]		24.2 – 32.5 [e]
Soybean	78.9 [c] 17.8 [c]		3.3 [c] 2.1 [c]	43.7 [c] 1.4 [c]	38.5 [c] 18.6 [c]
Palm Oil	19.7 [c] 21.7 [d]	3.8 [d]	2.1 [c] 4.7 [d]	1.4 [c]	20.4 [c] 29.5 [d]
Recycled Oils Animal Fats	10.7-16.5 [e]		3.0 [e]	1.2 [e]	14.5-20.1 [e]
2G Biodiesel	10-13 [a] 10.0 [c] 9.6 [c] 14.5 [d]	6.7	15-16 [a] 3.5 [c] 6.1 [c] 7.4 [d]	1.4 [c]	25-28 [a] 12.1 [c] 15.7 [c] 28.6[d]

[a] Szabo et al.. Assessment of the GHG reduction potential and cost curves resulting from fuel substitution possibilities
[c] Committee on Climate Change, UK
[d] Data from COWI's Danish model for alternative fuels, the A-D Model.
[e] ICF analysis.

Task 1.3: Costs in the baseline, biofuels

- Cost-effectiveness of abatement options (€/t)



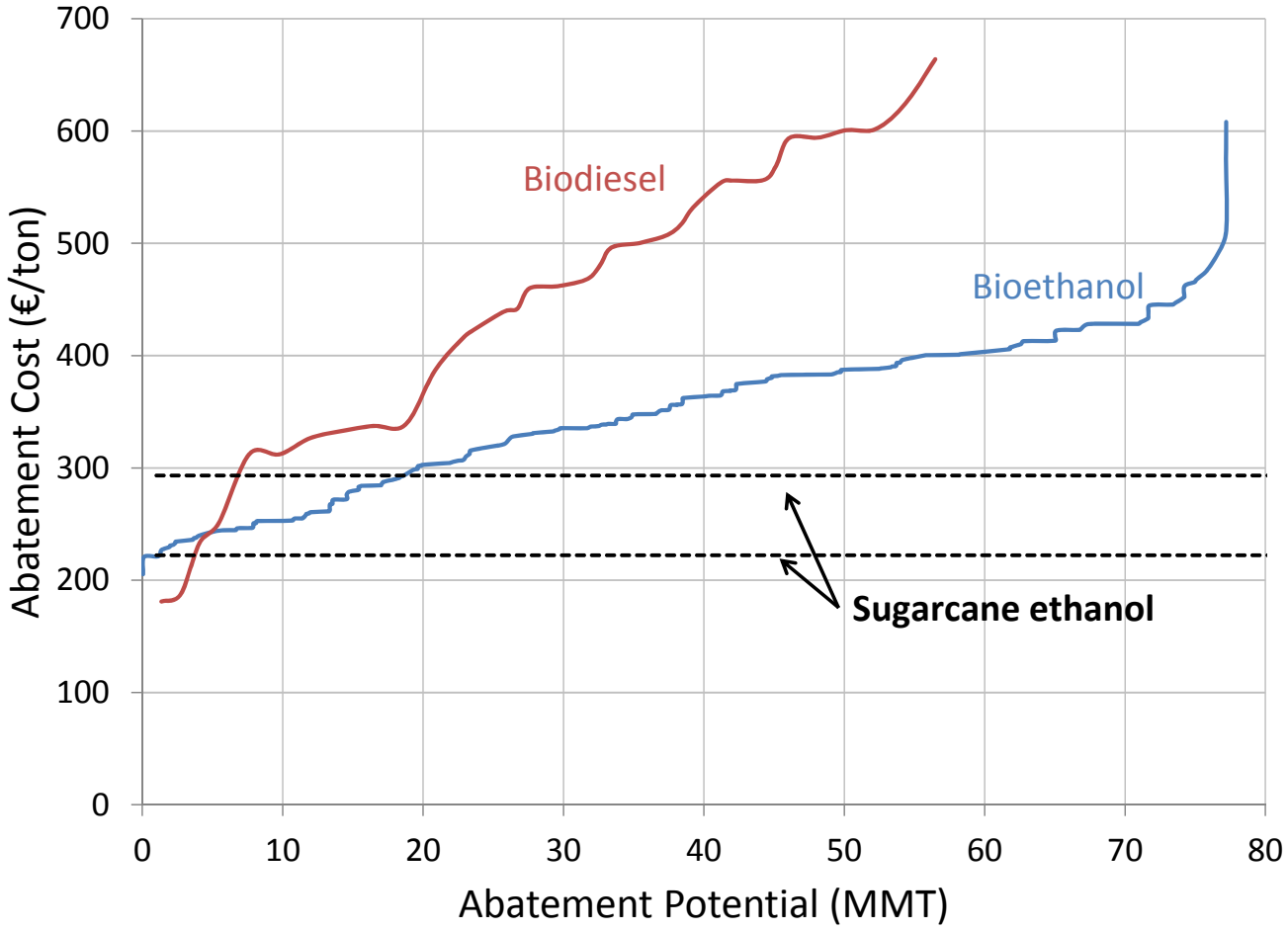
Task 1.3: Costs in the baseline, biofuels

Cost element	Description
Feedstock	Cost of the feedstock which varies by feedstock type
Transport	Cost of transporting the feedstock to the biofuel production facility
Operations	Cost of operating a biofuel production facility including energy use, water use, and other resource costs
Installed capacity	Amortized cost of installing biofuel production facilities
Byproducts	The byproducts of biofuel production often have value in other markets; these lower the overall marginal cost of producing some biofuels.

- Bioethanol feedstocks: corn, sugar beet, sugarcane, wheat, 2nd generation (land and non-land using)
- Biodiesel: rapeseed, sunflower, soybean, palm oil, recycled oils / animal fats, 2nd generation (land and non-land using)

Task 1.3: Costs in the baseline, biofuels (ctd)

- Abatement Cost Curves of Bioethanol and Biodiesel



Task 1.3: Costs in the baseline, upstream reductions

Upstream emission reductions

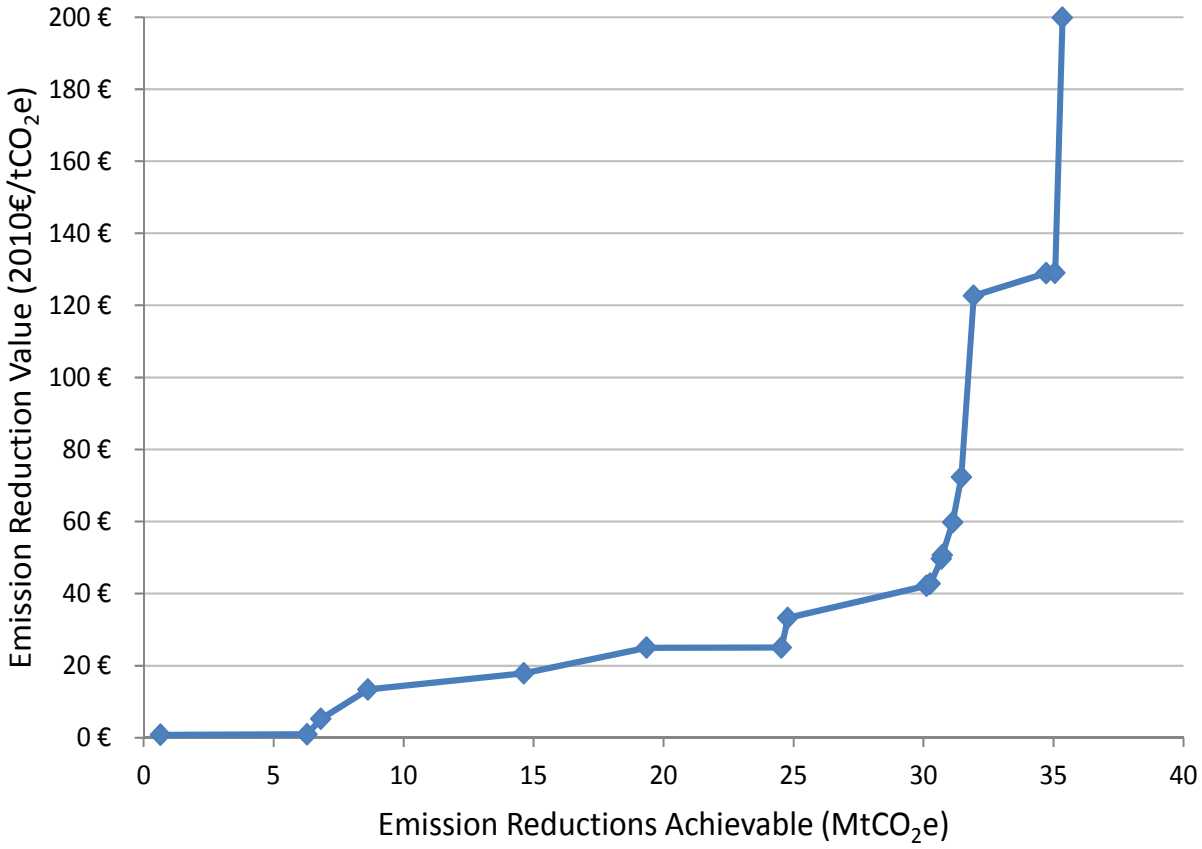
- Data taken from draft report for DG CLIMA
- What is the potential for reductions?
  - Identified 15 non-EU countries supplying crude to the EU in 2020

Country	Volume Flared (BCM)	Flared Emissions ($MtCO_2e$)
Russia	35.2	56.2
Azerbaijan	0.1	0.2
Turkmenistan	1.1	1.8
Venezula	2.8	4.5
Algeria	5.4	8.6
Libya	3.8	6.0
Egypt	1.5	2.3
Nigeria	15.2	24.2
Gabon	1.7	2.7
Angola	4.1	6.5
Zaire	1.9	3.0
Benin	NA	NA
Iran	11.3	18.0
Iraq	9.1	14.5
Saudi	3.1	5.0
Total	**96.3**	**153.5**
Source: GGFR		

Task 1.3: Costs in the baseline, upstream reductions

Upstream flare reductions, continued

- Although there is significant uncertainty regarding the potential for reductions in the future, ICF assumes that projects of similar size and cost could be implemented between 2010-2020.



Task 1.3: Costs in the baseline, summary

Strategy	Delta Energy (PJ)	GHG intensity (g/MJ)	Costs in Baseline (€, million)		
			low	high	best estimate
Bioethanol	147	143	2,342	3,426	2,851
corn	0	33.0	0	0	0
sugar beet	17	27.0	207	397	239
sugar cane	94	20.0	1,596	2,224	1,900
wheat	17	50.0	206	383	216
2G ethanol	19	13.0	353	594	496
Biodiesel	342	175	6,338	9,494	9,413
palm oil	110	40.0	1,973	2,852	2,801
rapeseed	151	40.0	2,509	4,305	4,564
soybean	16	47.0	251	338	367
sunflower	34	32.0	830	1,116	903
waste oils	0	9.0	0	0	0
2G biodiesel	31	7.0	775	883	794
Electricity	112	45.2	1,418	3,308	2,363
CNG	4	76.7	15	22	19
LPG	19	73.6	167	194	180
		Total	**10,279**	**16,445**	**12,545**

Task 1.3: Costs in the baseline, ILUC Sensitivity

- Extreme sensitivity scenario: Applied ILUC factors into sustainability criteria, displaced any biofuel that had a carbon intensity which did not achieve a 50% GHG reduction compared to fossil fuel

Strategy	Displaced Energy (PJ)	Increased Energy (PJ)	GHG reductions (Mt)	Best Estimate (€, million)
Bioethanol, wheat	30	--	--	-564
Biodiesel, palm	164	--	--	-3,928
Biodiesel, rapeseed	385	--	--	-10,033
Biodiesel, soy	105	--	--	-2,169
Biodiesel, sunflower	40	--		-1,040
Diesel, conventional	--	575	--	10,803
Bioethanol, 2G	--	30	2.3	75
Biodiesel, waste oil	--	54	4.3	20
Biodiesel, 2G	--	65	3.8	353
Methane flare reduction	--	--	34.0	838
		Total	44.4	-5,644

Comments welcome on:

- Revised BAU 2020 biofuel demand
- Revised BAU fossil feedstock splits
- Biofuel costs and availability
- Upstream reductions costs and availability

Questions?

Appendix

List of studies for preliminary assessment

SULTAN Tool

Impact of the use of biofuels on oil refining and fuels specifications, Wood Mackenzie

Transvisions, Report on Transport Scenarios with a 20 and 40 Year Horizon - Developing a set of longterm scenarios (2030-2050) for transport and mobility in Europe, European Commission DG TREN

Assessing the Land Use Change Consequences of European Biofuel Policies, IFPRI

Renewable Energy Projections as Published in the National Renewable Energy Action Plans (NREAP) of the European Member States, EEA

The World Energy Outlook 2012, International Energy Agency (IEA)

EU-27 Annual Biofuels Report USDA / GAIN

Global Energy Outlook, Platts Insight

List of studies (cont'd)

International Energy Outlook 2011, EIA/DOE (USA)

WORLD Model, EnSys

Europia White Paper on Fuelling EU Transport, A contribution from the EU refining Industry to the debate on the future of transport, European Petroleum Industry Association

Long Term Outlook for Gas Demand and Supply, Eurogas, The European Gas Industry

Energy Scenarios to 2050 (Scramble and Blueprint), Shell

Outlook for Energy: A View to 2040, ExxonMobil

World Oil Outlook, OPEC